Tertiary wastewater treatment using riparian wetlands: A curriculum guide for high school students

Robert Lee Norwood

TERTIARY WASTEWATER TREATMENT USING RIPARIAN WETLANDS: A CURRICULUM GUIDE FOR HIGH SCHOOL STUDENTS

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education:

Environmental Education

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by

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ABSTRACT

Information on the use of wetlands in the Santa Ana River Basin was developed to assist educators in presenting lessons and activities to high school students on this wetland area and the local wastewater treatment process. Topic areas for lessons include characteristics, benefits, and protection of wetlands; properties of water; the water cycle; water quality; wastewater treatment; and the Hidden Valley Wildlife Area. The curriculum incorporates constructivist teaching methodology as an approach to teaching environmental education.

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DEDICATION

With all my love to my wife Kathy,
and Kevin, Heather, Dustin, Amber, and Keith,
not forgetting all those who, during the
writing of this project, put up
with my presence or absence,
as the case may be.

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Introduction

Changes made by the Santa Ana Regional Water Quality Control Board in 1991 reduced the allowable nitrogen levels of effluent discharges into the Santa Ana River. In response to these new regulations the City of Riverside chose to incorporate the "natural" nitrogen removal capabilities of the wetland ponds found in the Hidden Valley Wildlife Area of Riverside as the method to meet the new standards. As part of an agreement with the County of Riverside and the California Department of Fish and Game, existing ponds were repaired and restored and new ponds were built in the wetlands within the Hidden Valley Wildlife Area. Other improvements were also made by the City of Riverside to the areas surrounding the ponds and the 1500 acre Hidden Valley Wildlife Area.

This cost-effective method of reducing nitrogen levels has proven to be very successful while at the same time improving and restoring important wetland habitat.

The County of Riverside, through the Parks and Open Space District, along with the City of Riverside, are responsible for public education concerning the utilization of the wetlands and wastewater treatment. Currently there is limited curriculum available for high school students on this topic.

This project includes background information and lessons for high school students involving wetlands in the Hidden Valley Wildlife Area. The background information for wetlands includes soils, vegetation, benefits, and protection of wetlands. Other background information includes properties of water, the water cycle, water quality, the nitrogen cycle, arundo infestation, governing agencies, laws and regulations, the Hidden Valley Wildlife Area, the Wetland Enhancement Project, and the Riverside Regional Water Quality Treatment Plant. The curriculum will prepare and support teachers while enabling students to be knowledgeable about and able to investigate this local environmental issue.

Literature Review

Introduction

A review of recent literature sources validates the importance of environmental education in the development of environmental awareness, knowledge, attitudes, and problem solving skills within students at the middle school and high school educational levels. These sources also suggest that educational trends toward alternative teaching methodologies and settings are successfully incorporating environmental education goals, objectives, methods, skills, and outcomes into new curricula.

The importance of environmental education has been recognized by the United States Congress. The following passage from section 2 of the National Environmental Education Act of 1990, describes the United States' policy toward environmental education:

> It is the policy of the United States to establish and support a program of education on the environment, for students and personnel working with students, through activities in school, institutions of higher education, and related educational activities (Public Law 101-619).

Beginnings of Environmental Education

Although the National Environmental Education Act of

1990 was not the first act of its kind to be signed into law, it signaled a needed renewal of commitment by the federal government toward environmental education (Marcinkowski, 1990, p. 7). The beginnings of environmental education are rooted in the existence of earlier environmental movements with labels such as conservation education and outdoor education (Disinger, 1993, p. 24). As early as the mid-1800s, educator Louis Agassiz proposed that his students should not study from books, but instead "study nature" (Disinger, 1993, p. 25). Disinger (1993) reported that the "dust bowl" of the 1930s caused an awareness of natural resource problems and, consequently, conservation education which emphasizes conservation of natural resources. In the early 1960s, in reaction to Rachel Carson's bestseller Silent Spring in 1962, local, state, and federal laws, policies, and curriculum related to environmental education were begun (Disinger, 1993, p. 24).

Characteristics of Environmental Education

Environmental educators have developed goals for environmental education that share common ideals concerning the development of attitudes, knowledge, and skills for environmental actions. In a meta-analysis of research conducted over the past 20 years, Iozzi (1989) found environmental education programs developed positive, long lasting environmental attitudes and values. According to the goal statement of the nationally acclaimed wildlife curriculum guide, Project WILD (1992, p. vi), environmental education should "assist learners" to develop "awareness, knowledge, skills, and commitment" that will result in positive decisions, behaviors, and actions concerning the environment.

Ramsey, Hungerford, and Volk (1992) pointed out the necessity of environmental education as preparing an "individual to be responsive to a rapidly changing technological world, to understand contemporary world problems, and to provide the skills needed to play an effective role in the improvement and maintenance of the environment" (p. 36). Schaefer (1992) also advocated the importance of environmental education, stating that "environmental education exists to produce educated citizens who will understand the natural environment and contribute to protecting its health and diversity" (p. 6).

Environmental education also seeks to build connections between people and their surroundings, especially those who are physically removed or unable to experience the natural world that surrounds them. Schaefer (1992) emphasized that people who live in cities view themselves as separated from nature, and that environmental education can impart an "appreciation of how cities relate to natural ecosystems" (p. 6).

Characteristics of Outdoor Education

The role of outdoor education is discussed in literature as an effective approach or method of instruction utilizing the out-of-doors for environmental awareness, knowledge, attitudes, and skills concerning environmental problems and issues. Few differences can be found between outdoor education and environmental education. Both share common objectives of increasing awareness and knowledge, developing attitudes, critical thinking skills, and action skills related to the environment (O'Brien & Stoner, 1987: Project WILD, 1992; Ramsey, Hungerford & Volk, 1992; D. Stoner, personal communication, 1996). Disinger (1993) described outdoor education as an approach to teaching environmental education rather than a singular goal or a content area to be taught. He gave credit for outdoor education to the progressive education movement of the 1930s, whose belief in "learning by doing" was translated in environmental education to "learning about the environment in the environment" (p. 26). Disinger (1993) best summed up the essence of outdoor education, citing a quotation from L.B. Sharp, "teach outdoors what is best learned outdoors, and indoors what is most appropriate there" (p. 26).

A review of several studies found that outdoor and environmental education are well suited for teaching local solutions to local problems, for empowerment of students, and for affecting attitudes and values (Schaefer, 1992). Schaefer (1992) pointed out that the popular phrase "think globally, act locally" should be instead "think locally, act locally," creating a relevant context for the student that allows the student of define their role within the confines of a local ecosystem (p. 5). He found that locally focused projects were successful and motivating for students when the projects focused directly on the students surroundings.

The Constructivist Connection

Many sources of literature refer to the components of constructivism and how those components can be found in environmental education curricula. Orr (1994) succinctly explained the constructivist philosophy when he stated "the way in which learning occurs is as important as the content of particular courses" (p. 14). According to Knapp and others (Knapp, 1992; American Forest Foundation, 1994; D. Stoner, personal communication, 1996) the constructivist model of education consists of the main concept that students construct new understanding or reality based upon their prior views or perceptions, combined with new knowledge and experiences. Constructivists view every student as having different perceptions, beliefs, cultural backgrounds, conceptions and misconceptions, knowledge, and experiences that will affect and influence student learning (Brody, 1990; Knapp, 1992). Munson (1994) explained that these prior perceptional differences affect a student's understanding, acquisition, development, and interpretation of additional knowledge.

The constructivist curriculum is presented from whole to part, putting emphasis on the primary or larger concepts rather than the small details (Brooks, 1990; D. Stoner, personal communication, 1996). Brooks (1990) found that teachers using the constructivist model or environmental education model need to recognize differing student "realities," misconceptions, and understandings before they can proceed forward in helping students develop new conceptual learning (pp. 68-70). Clough and Clark (1994) found that certain constructivist teacher behaviors are important and effective. These behaviors include providing questions designed to make students elaborate their ideas, using encouragement, lots of observation, and actively listening to students (p. 37). Klein and Merritt (1994) pointed out parallels between environmental education and constructivism in areas such as active learning and building on facts, problem solving, and critical thinking skills.

They believe that every component of constructivism can be found in the activities of environmental education curriculum (p. 20). Klein and Merritt (1994) also explained that not only have environmental educators been using components of constructivism for many years, but that educators, in general, have been experimenting with constructivist concepts for some time (p. 16).

Encouraging Environmental Education in the Classroom

Comprehensive environmental lessons and activities that can be used in both indoor and outdoor settings will prove helpful in encouraging more teachers to incorporate environmental education into their classrooms. O'Brien and Stoner (1987) emphasized that the term "environmental education" was perceived as intimidating by teachers. They also noted that teachers feel unequipped or unprepared to teach environmental education because of a lack of information and experience on the subject. Simmons (1993) found that surveys of teachers supported concerns about a lack of knowledge and skills, but on the other hand the surveys also showed that teachers believe that nature experiences are important and relevant. She found from the teacher surveys that teachers preferred to take students to "places with unpaved trails, woods, and areas conveying a sense of solitude or being out in the wild" (p.8), but usually teachers did not use these settings when teaching about nature. Simmons (1993) concluded that teachers need training to learn about how to use outdoor settings; otherwise they "will rely on their previous experience or stereotyped ideas of what can be accomplished in a particular setting" (p. 10).

Summary

Much of the research literature previously mentioned in this review supports the need for locally developed, environmental education curricula that prepares and supports teachers while, at the same time, produces students who are knowledgeable, committed, and possess the skills to investigate local environmental issues and solve local environmental problems.

Background Information for Teachers

An Overview of Wetlands

What is a Wetland?

Wetlands are typified by areas with water-logged soils or standing water that remains for prolonged periods during the year (American Forest Foundation, 1994, p. 258). The water sources for these wetlands can vary from rivers, streams, lakes, and ponds to agricultural runoff, wastewater discharge, and the ocean (The Watercourse & Western Regional Environmental Education Council [WREEC], 1995, p. 133).

The United States Fish and Wildlife Service defines a wetland in terms of the type of habitat that can be found in the transition between upland and aquatic environments, where the water level is just beneath, at, or slightly above the surface of the soil (National Wildlife Federation, 1984, p. 180; Niering, 1985, p. 21). Grah and Grah (1989), in describing a wetland, use the federal government's definition of wetlands: areas that are covered or saturated by water for a length of time long enough to support vegetation that can tolerate or requires wet or saturated soil conditions (p. 4).

For the purpose of defining a wetland the Santa Ana Regional Water Quality Control Board (1995), the agency responsible for protecting all wetlands in the Santa Ana

River Basin, acknowledges three general characteristics of wetlands: hydrophytic vegetation, hydric soils, and wetland hydrology (p. 3-3). Wetlands are classified by scientists and government agencies into two major types, estuarine and palustrine, based upon the characteristics of the water, soils, types of vegetation, and location or proximity to water (National Wildlife Federation, 1984, p. 180; Niering, 1985, p. 21; Williams, 1996, p. 47). Water is the major criteria for classifying wetlands and includes inland freshwater (palustrine) systems such as rivers, streams, lakes, ponds, marshes, and swamps that constitute 90% or 97.8 million acres of the United States' remaining wetlands (American Forest Foundation, 1994, p. 258; Niering, 1985, p. 21). Wetlands are also found in coastal saltwater (estuarine) systems that include saltwater marshes, mangrove swamps, and tidal flats that comprise the 5.5 million remaining acres of United States wetlands (American Forest Foundation, 1994, p. 258; National Wildlife Federation, 1984, p. 180).

Wetland Soils.

Wetland soils are classified as hydric soils. These soils are oxygen-depleted due to the prolonged periods of water saturation (Santa Ana Regional Water Quality Control Board [Santa Ana RWQCB], 1995). The soils commonly found in wetland areas can be high in organic matter resulting from the decay of plants and animals or high in mineral content of sands, silts, and clays (The Watercourse & WREEC, 1995, pp. 212-213). The organic soils tend to be more acidic than the purely mineral soil types but both provide an anaerobic environment due to the prolonged presence of water and both act as a storage reservoir for water (The Watercourse & WREEC, 1995, pp. 212-213).

Wetland Vegetation.

The vegetation found in wetland areas can vary greatly depending upon the amount, duration, and quality of water and the type of soils present. Wetland vegetation can be classified as hydrophytic or "water loving" plants that can tolerate or require long periods of contact with water or water saturated soils (Jablonski, 1989, p. 9). These aquatic plants are divided into three groups: emergents, floaters, and submergents. Emergent plants are amphibious, with the ability to grow with their lower portions submerged in water while their upper portion is out of the water (Jablonski, 1989, p. 9; Niering, 1985, p. 21). Cattails and reeds are a common example of emergent wetland vegetation. Plants that float freely on the water surface or are rooted on the bottom with leaves extending to the surface are classified as floaters (Jablonski, 1989, p. 9). The water hyacinth is a very common floater in wetland areas. The third group of wetland plants are classified as submergents because they live solely underwater. Their plant structure is different from terrestrial plants and this enables submergents to directly absorb nutrients, water, and gases for photosynthesis directly from the water through small, thin leaves (Jablonski, 1989, p. 10). The different types of wetlands--marshes, ponds, rivers, swamps, and tidal flats--are home to a variety of different wetland plants that can grow only in a specific type of wetland. Marshes are home to plants that are typically herbaceous or "soft-stemmed." Such plants include water lilies, cattails, grasses, and sedges (Grah & Grah, 1989, p. 5). In swamps, river flood plains, and streams the dominant plants are woody-stemmed plants including hardwood trees such as willows, cottonwoods, maples, alders, gums, and ashes (Grah & Grah, 1989, p. 5; Niering, 1985, pp. 22-23).

Benefits of Wetlands.

The benefits of wetlands range from creating natural habitats for plants and animals to filtering and removing pollutants.

In terms of wildlife benefits, wetlands provide: (a) nesting, feeding, and wintering sites for waterfowl; (b) food, water, and cover for game and fur bearing species; and

(c) breeding grounds for two thirds of commercial fish and shellfish (Niering, 1985, pp. 19-35; United States Fish & Wildlife Service, 1982).

The benefits relating to water conservation and water resources include water purification, wastewater treatment, removal of pollutants and sediments, recharging of groundwater supplies, flood control, and erosion control (Niering, 1985, p. 19-35; U.S. Fish & Wildlife Service, 1982; Santa Ana RWQCB, 1995). Water purification is an important aspect of wetlands. The ability of wetlands to slow down rushing flood waters laden with sediments and impurities allows the sediments to settle out around the roots of trees and plants preventing sediments from adversely affecting aquatic life or burying the eggs of aquatic animals (American Forest Foundation, 1994, p. 258). The wetland's ability to slow down and allow for the spreading of flood waters can control flooding and protect valuable land and structures below or beyond wetland areas (American Forest Foundation, 1994, p.258; Williams, 1996, pp. 98-99).

Wetlands also have the ability to chemically purify or "polish" water by removing or reducing pollutants such as nitrogen compounds through denitrification of effluent discharged by water quality treatment plants. This results in harmless nitrogen compounds that can be used by plants or elemental nitrogen (N_2) that escapes into the atmosphere (Claus, McPherson, Thakral & Tseng-Chen Lai, 1996, p. 37; Santa Ana RWQCB, 1995, p. 3-4; Williams, 1996, p.50).

Protection of Wetlands.

Despite laws protecting wetlands, the United States is experiencing wetland losses that outpace protection and restoration (Dahl, 1990, p. 5). Over the past 200 years the United States and, in particular California, have experienced severe losses of existing wetlands (Dahl, 1990, p. 5; Williams, 1996, pp. 45-47). Dahl (1990) of the United States Fish and Wildlife Service, in his report to Congress, cited data that indicate the loss of wetlands in the lower 48 states to be an estimated 53% (p. 1). California leads the losses, losing a whopping 91% of its original 5 million acres--leaving a mere 454,000 acres that infuse an estimated 10 billion dollars into the California economy (Williams, 1996, p. 45).

The policy of wetland destruction in the United States dates back to the colonial period when swamps were "considered wastelands to be drained, filled, or manipulated" (Dahl, 1990, p. 2) and converted into agriculturally usable land. The Bureau of Reclamation was created by Congress in 1902 with the purpose of reclaiming wetlands (Williams, 1996, p. 47).

Williams reported that the Clean Water Act of 1977 was amended to require the United States Army Corps of Engineers to forbid the drainage and filling of wetlands, but this law has little enforcement and allows developers to easily obtain legal permits to destroy wetlands (Williams, 1996, pp. 46-47). Currently laws and regulations are being written that weaken, instead of strengthen, the current protection of existing wetlands (Williams, 1996, p. 47).

The California Wetlands Conservation Policy was announced by Governor Pete Wilson in 1993 and promoted three main objectives: (a) to ensure no overall net loss of wetlands while achieving a long-term gain in quantity, quality, and permanence of wetlands; (b) to simplify the complex and confusing administration of wetlands conservation programs; and (c) to redirect the primary focus of wetlands conservation and restoration toward landowner incentives and cooperative planning (Santa Ana RWQCB, pp. 3-5).

Hydrology

As previously mentioned, water plays important roles in a wetland. Without water, producing hydric soils and providing habitat for hydrophytic vegetation and animal life, wetlands could not exist. Water is a valuable resource that is needed by all living organisms--plants, animals, bacteria, fungi, and protozoans. Water is important to humans as well for drinking, producing food, industry, and recreation (Lee & Turner, 1997, p. 6).

Location of water.

Nearly 71% of the earth's surface is covered with water, but much of that water, around 97%, is saltwater found in the oceans of the world (American Forest Foundation, 1994, p. 142; Lee & Turner, 1997, p. 62). The remaining 3% of the earth's water is freshwater, but two thirds of this freshwater is found as ice and snow in glaciers and icecaps covering the north and south poles (Fariel, Hinds, Berey & Barr, 1989, p. 337; Lee & Turner, 1997, p. 62). Most of the nearly 1% of remaining freshwater can be found on or under the ground, with just 1/1000 of a percent to be found in the atmosphere (Fariel et al., 1989, p. 337).

Properties of Water.

Water has unique properties. It can be found naturally in all three forms of matter, solid (as ice), liquid (as water), and gas (as steam or water vapor)(Fariel et al., 1984, p. 337; Lee & Turner, 1997, p. 62). Water has the ability to: (a) freeze, changing from a liquid to a solid; (b) condense, changing from a gas to a liquid;

(c) evaporate, changing from a liquid to a gas; and (d) melt, changing from a solid to a liquid (Fariel et al., 1989, p. 337).

The Water Cycle.

Water circulates and is recycled from the earth's surface, to the atmosphere, and back to the earth's surface. This cycle is called the water cycle or hydrologic cycle (Fariel et al., 1989, p. 338; Lee & Turner, 1997, p. 62). The water cycle begins as the sun's energy transforms liquid water on the earth's surface into a gas or vapor in a process called evaporation (Fariel et al., 1989, pp. 337-338; Lee & Turner, 1997, p. 62). The water vapor is drawn up into the atmosphere and as it rises it begins to cool and condense, forming tiny water droplets in clouds (Lee & Turner, 1997, p. 62). As the tiny droplets cool even further they become larger until they can no longer be suspended in the atmosphere and fall to the earth's surface as precipitation in the form of rain or snow (Fariel et al., 1989, p. 338; Lee & Turner, 1997, p. 62). Most of the precipitation that falls back to the earth falls into the oceans to begin the cycle again. Of the rain and snow that falls on the land areas of the earth, some will evaporate back into the atmosphere, while some will soak into the ground to become underground water. Water may stay on the surface as wetlands, lakes, and ponds or run off in streams and rivers back to the oceans (Fariel et al., 1989, pp. 337-347; Lee & Turner, 1997, p. 62).

Water Quality.

Mitchell and Stapp (1986) pointed out the importance of water quality in determining the safe use of water (p. 9). They believe that because the quality of water can have "significant social, economic, and environmental implications" (p. 9), it is important to constantly monitor and maintain water quality.

The Santa Ana Regional Water Quality Control Board (RWQCB) is responsible for establishing the water quality standards and objectives for the Santa Ana River Basin and these standards and objectives are found in their publication, the Regional Water Quality Control Plan (Santa Ana RWQCP) (Santa Ana Regional Water Quality Control Board, 1995, p. 4-1). The RWQCB must consider several factors when establishing water quality standards or objectives. These include (a) assuring reasonable protection of beneficial uses; (b) the historical water quality and availability; (c) establishing coordinated control of factors affecting water quality; (d) economic considerations; (e) expansion of housing developments; and (f) the development and use of recycled water (p. 4-1).

The Santa Ana RWQCB (1995) has determined over 27 separate factors that influence water quality. These factors include:

1. Algal growth
2. Un-ionized (inorganic)ammonia
3. Coliform bacteria
4. Boron concentrations
5. Chemical oxygen demand (COD)
6. Chloride concentrations
7. Residual chlorine
8. Color
9. Total dissolved solids (TDS)
10. Floatables
11. Fluoride concentrations
12. Hardness (calcium carbonate, $CaCO_3$)
13. Metals
14. Nitrate concentrations
15. Inorganic nitrogen
16. Oil and grease
17. Dissolved oxygen
18. pH
19. Radioactivity
20. Sodium concentrations
21. Solids
22. Sulfides concentrations
23. Surfactants
24. Taste and odor
25. Temperature
26. Toxic substances
27. Turbidity

The Santa Ana RWQCB sets the maximum allowable levels of these factors for any effluent discharged into the Santa Ana River Basin (Santa Ana RWQCB, 1995, p. 4-25).

The National Sanitation Foundation (NSF) formulated a standard index called the Water Quality Index (WQI). The NSF uses this index to measure water quality changes in bodies of water such as lakes, ponds, and rivers (Mitchell & Stapp, 1986, p. 11). There are 9 factors that are tested to determine the WQI. These test values are weighted on a special weighting curve chart to produce a numerical value for each test, then the values are added together to produce the overall water quality index. The 9 factors that are tested for the NSF-WQI are dissolved oxygen, fecal coliform, pH, biochemical oxygen demand, temperature, total phosphorus, nitrates, turbidity, and total solids (Mitchell & Stapp, 1986, p. 12).

The daily testing plan set by the Riverside Regional Water Quality Treatment Plant (RRWQTP) involves nine similar sampling and testing procedures to determine the water quality of the effluent discharge from the treatment plant and of the Hidden Valley Wetlands (Claus et al., 1997, p. 36). These water quality factors include (a) total organic nitrogen (TIN); (b) chloride (Cl); (c) sodium (Na); (d) chemical oxygen demand (COD); (e) sulfates (SO_4); (f) hardness ($CaCO_3$); (g) total dissolved solids (TDS); (h) water temperature; and (i) influent and effluent flow rates (Claus et al., 1997, p. 39; Santa Ana RWQCP, 1995, p. 4-25).

The water quality factors, in milligrams per liter (mg/L), are set forth by the Santa Ana RWQCB for Reach 3, which includes the Hidden Valley Wetlands and Wildlife Area (Santa Ana RWQCB, 1995, p. 4-25). The maximum amounts allowable (found in parentheses as mg/L) are TDS (700), $CaCO_3$ (350), Na (110), Cl (140), TIN (10), SO_4 (150), and COD (30) (Santa Ana RWQCB, 1995, p. 4-25).

State and Local Agencies, Laws, and Regulations

The Santa Ana River Basin is controlled and protected by the Santa Ana Regional Water Quality Control Board (Santa Ana RWQCB) and is a sub-unit of the larger state agency, the State Water Resources Control Board (SWRCB)(Santa Ana Regional Water Quality Control Board [Santa Ana RWQCB], 1995, p. 1-1). Both the SWRCB and the Santa Ana RWQCB were established by the Porter-Cologne Water Quality Control Act (Santa Ana RWQCB, 1995, pp. 1-1, 1-5). The SWRCB sets statewide water policy and works together with the Santa Ana RWQCB to implement state and federal laws and regulations.

The Santa Ana RWQCB is required by the Porter-Cologne Water Act and the federal Clean Water Act to develop the "Basin Plan" for the Santa Ana River Basin and establish "water quality standards for all ground and surface waters in the region" (Santa Ana RWQCB, 1995, pp. 1-1, 1-5). The Basin Plan is the basis of the Santa Ana RWQCB's regulatory programs and includes water quality goals and policies, descriptions of conditions, and discussion of solutions concerning water in the region (Santa Ana RWQCB, 1995, p. 1-1). Another important aspect of the Santa Ana RWQCB is that it regulates wastewater effluent discharges into the Santa Ana River Basin in order to control the water quality in the region (Santa Ana RWQCB, 9195, p. 1-1).

The SWRCB has divided the Santa Ana River into six Reaches that are each considered an individual hydrologic and water quality unit (Santa Ana RWQCB, 1995, p. 1-6). Reach 3 of the Santa Ana River incorporates the portion of the river from the Mission Bridge to the Prado Dam, including the "Narrows," where the Hidden Valley Wildlife Area is located (Santa Ana RWQCB, 1995, p. 1-9).

<u>The Hidden Valley Wildlife Area</u>

<u>History.</u>

The <u>Water Quality Control Plan</u> for the Santa Ana River Basin describes the river before the influences of modern humans as a perennial flowing river where, due to geologic features in certain places, groundwater was forced to the surface to create natural springs and wetland areas such as swamps, marshes and bogs (Santa Ana RWQCB, 1995, p. 1-4). Due to agricultural and urban consumption of local groundwater supplies over the past 100 years, combined with flood control measures and urban encroachment, this description has changed greatly, to the detriment of the wetlands(Santa Ana RWQCB, 1995, p. 1-4). Presently most of the historic wetland areas do not exist due to the reduction of groundwater levels. The visible surface water found in the river is the result of treated wastewater effluent discharged into the river by cities such as the City of Riverside, which discharges all or part of its 15 million gallon per day effluent flow through the ponds in the Hidden Valley Wildlife Area or directly into the river channel (Santa Ana RWQCB, 1995, pp. 1-7 to 1-9).

The Riverside County Parks and Open Space District has operated the Hidden Valley Wildlife Area (HVWA) since its purchase in 1974 by the state of California (City of Riverside, 1995, p. 2-1). Between 1957 and 1974 the area was privately owned by a gun club called the Hidden Valley Gun Club (City of Riverside, 1995, p.2-1).

Facilities.

Presently the HVWA encompasses an area of approximately 1500 acres with approximately 200 acres of constructed wetland ponds ranging in depths from 6 inches to 5 feet (City of Riverside, 1995, p. 2-1). Buildings on the site were built by the gun club and include the park ranger's office, an equipment storage area for the farmer, and the former gun club's "duck club" building (City of Riverside, 1995, p. 2-3). The building has been refurbished by the city and is now used as the nature center for the HVWA (City of Riverside, 1995, p. 2-3).

Cooperative Management.

The County of Riverside has a 50 year agreement with the California Department of Fish and Game, the actual landowner, to operate the HVWA as a public use area (City of Riverside, 1995, p. 2-1). Riverside County and the City of Riverside have a 30 year agreement for the "supervision and general maintenance of the of the Wetland Enhancement Project" (City of Riverside, 1995, p. 2-4) located with the HVWA. Through this agreement the county will provide area security, public education, and help in removing the arundo and other vegetation. The City of Riverside has agreed to build additional wetland areas, restore riparian habitat, provide a reliable water supply, provide salaries for a park ranger and a park naturalist, and improve the public day use areas and nature center (City of Riverside, 1995, pp. 1-2, 1-3, 2-4).

About 205 acres of the HVWA are privately farmed under an agreement with the County of Riverside and the California Department of Fish and Game (City of Riverside, 1995, p. 2-3). In this agreement the farmer can grow a crop such as corn on the leased land for a portion of the year, and then must grow a grain forage crop that migrating Canada Geese can eat during their stopover at the HVWA (City of Riverside, 1995, p. 2-3). The farmer also must help with the labor, equipment and fuel necessary for the maintenance of the HVWA (City of Riverside, 1995, p. 2-3).

The Wetland Enhancement Project

The Wetland Enhancement Project (WEP) has the objective of restoration and improvement of the existing wetlands in the HVWA to maximize their use for "polishing" the effluent from the Riverside Regional Water Quality Treatment Plant while enhancing the wetland environment (City of Riverside, 1995, p. 2-4).

On completion of the WEP the City of Riverside expects several benefits to the project. These benefits include (a) denitrification of effluent from the Riverside Water Quality Control Plant; (b) restoration of high-quality riparian habitat; (c) groundwater recharge; (d) improved public day use areas and nature center; (e) improved management of the HVWA; (f) a consistent water source; and (g) increased opportunities for scientific research, development, and public education (City of Riverside, n.d.a; City of Riverside, 1995, pp. 1-3, 1-4).

The WEP was completed through a variety of enhancement projects that include ensuring adequate water flow, plant growth, open water areas, water percolation, arundo removal, and conversion of farmland into productive wetland ponds (City of Riverside, 1995, p. 2-4). The City of Riverside built new influent and effluent structures, conveyance channels, a pedestrian bridge, and wetland ponds (City of Riverside, 1995, pp. 2-4 to 2-6). The five newly constructed ponds were completed in 1995 and cover an area of 23 acres (Claus et al., 1997, p. 35). The ponds were constructed with shallow and deep areas that control the native emergent vegetation, cattails and bulrush, that were transplanted from other ponds in the HVWA (City of Riverside, 1995, p. 2-7). Deeper water inhibits the growth of emergent vegetation and maintains open water areas for waterfowl, which was part of the agreement with the California Department of Fish and Game (J. Claus, personal communication, April 25, 1997). In addition to the five new ponds, eight existing ponds covering 37 acres underwent similar improvements for a total of 70 acres of wetlands ponds (Claus et al., 1997, p. 35).

The WEP was a result of two contributing factors. First was a study by the University of California at Riverside, that showed the potential for nitrogen removal through natural bacterial actions and plant uptake, using constructed wetlands in the HVWA (City of Riverside, n.d.a; J. Claus, personal communication, April 25, 1997). The second factor came in the form of a new regulation, adopted by the Santa Ana RWQCB in 1991, that reduced the allowable levels of total inorganic nitrogen (TIN) in the effluent to

13 mg/L (Claus et al., 1997, p. 36). This new regulation forced the City of Riverside to choose between building additional nitrogen removal facilities at an estimated cost of $23 million dollars with an annual operating costs of $160,000 dollars, or utilizing the adjacent wetlands, creating ponds at an approximate cost of $2 million dollars (Claus et al., 1997, p. 41). The answer was obvious in terms of investment and benefits to both the City of Riverside and Hidden Valley Wildlife Area.

In addition to the construction or restoration of 15 ponds in the HVWA, the city removed about 20 acres of non-native arundo and replaced it with native vegetation, improved roads, trails, and signs, and developed educational and interpretative programs for the public and local schools (City of Riverside, n.d.a; J. Claus, personal communication, April 25, 1997).

J. Claus (personal communication, April 25, 1997) reported that the wetland ponds had exceeded the denitrification requirements, bringing the total inorganic nitrogen (TIN) level below the target level of 13 milligrams per liter, to a combined average of approximately 10 mg/L. He also said the city plans to increase the wetland capacity by restoring two more existing ponds and possibly building more ponds on land presently being used for agriculture.

The Riverside Regional Water Quality Treatment Plant

Wastewater from the City of Riverside and the Jurupa, Edgemont, and Rubidoux Community Services Districts is transported via the sewer system to the Riverside Regional Water Quality Treatment Plant (RRWQTP) located about a mile upstream from the Hidden Valley Wildlife Area. This untreated wastewater is filtered, processed, treated, and disinfected before being released--in a series of processes that can be generalized into three major treatment phases; primary treatment, secondary treatment, and tertiary treatment (City of Riverside, n.d.b).

Primary Treatment.

Wastewater first travels through the primary treatment portion of the water quality treatment plant where it passes through bar screens that remove large objects that would disrupt further processes. From the bar screens the wastewater enters the headworks grit chambers where smaller particles settle out and are removed (City of Riverside, n.d.b). The residue from these two processes is automatically collected and incinerated. The screened and filtered wastewater then travels to the primary sedimentation tanks where a majority of the suspended solids are allowed to settle out (City of Riverside, n.d.b). The residue from the primary sedimentation tank is collected and sent to the anaerobic digester to be further processed.

Secondary Treatment.

From the primary sedimentation tanks the wastewater is transferred for secondary biological treatment to the biological aeration tanks. The secondary biological aeration tanks utilize the natural processes of aerobic microorganisms to consume around 90% of the remaining organic material (City of Riverside, n.d.b). These tanks are injected with air to enhance the microorganism's abilities to grow and consume the organic material in the wastewater. As the microorganisms grow and reproduce they help purify the wastewater by metabolizing the organic material and using it for growth and reproduction. This results in increased amounts of microorganisms and decreased amounts of organic material as it is consumed by the microorganisms. The microorganisms are collected in a secondary sedimentation tank and are recycled into the secondary biological aeration tanks or reduced into a thick sludge and sent to the anaerobic digester for processing (City of Riverside, n.d.b; J. Claus, personal communication, April 25, 1997).

Tertiary Treatment.

After the secondary biological aeration removes nearly all the organic material and microorganisms the wastewater is transferred to the flow equalization basins before entering the final tertiary treatment phase (J. Claus, personal communication, April 25, 1997; City of Riverside, n.d.b).

In the tertiary treatment process the wastewater is passed through an activated charcoal filter system that removes minute suspended particles and viruses (City of Riverside, n.d.b; J. Claus, personal communication, April 25, 1997). By this point in the overall treatment process 97% of the suspended solids and 98% of the biological oxygen demand--a measurement of the amount of organic material--have been removed (City of Riverside, n.d.b).

The treated wastewater is then sent to the chlorine contact tanks where it is injected with chlorine to disinfect for bacteria and viruses that may remain in the wastewater (City of Riverside, n.d.b; J. Claus, personal communication, April 25, 1997). The chlorine in the water would prove toxic to organisms, so the final effluent or reclaimed water is dechlorinated before being released into the Santa Ana River (J. Claus, personal communication, April 25, 1997).

The sludge generated by the primary and secondary phases is processed in the anaerobic digester and then pressed to remove excess water before being moved to drying beds where even more water is removed (City of Riverside, n.d.b; J. Claus, personal communication, April 25, 1997). The treatment plant currently produces about 21 dry tons of sludge every day, which is removed by a local farmer and used as a soil amendment and fertilizer in his farming operations (City of Riverside, n.d.b; J. Claus, personal communication, April 25, 1997).

Biology

The Nitrogen Cycle.

Although nitrogen makes up 78% of the earth's atmosphere most living organisms cannot use nitrogen (N_2) in this gaseous form (Towle, 1989, p. 789). The nitrogen cycle consists of four processes that convert atmospheric nitrogen gas into nitrogen compounds--nitrates and nitrites--that can be used by plants and animals, and eventually recycled back into the atmosphere . The four major processes are (a) nitrogen fixation, (b) ammonification, (c) nitrification, and (d) denitrification (Towle, 1989, p. 789).

The first phase, nitrogen fixation, is accomplished primarily by bacteria that live in nodules on the roots of legume plants such as alfalfa, clover, peas, and beans (Towle, 1989, p. 789). These bacteria have the ability to "fix" nitrogen (N_2) and convert it into ammonium compounds (Towle, 1989, p. 789). Lightning during storms will also fix or chemically change atmospheric nitrogen to form ammonium compounds.

The second phase in the nitrogen cycle is ammonification--the bacterial (anaerobic) decomposition of nitrogen compounds found in animal wastes and dead organisms--which also forms ammonium compounds (Towle, 1989, p. 790). It is similar to nitrogen fixation except that the nitrogen is from organic sources not the atmosphere.

The third phase of the cycle is nitrification. A different type of bacteria (aerobic) metabolizes and oxidizes ammonia compounds produced from nitrogen fixation and ammonification, to form nitrates (NO_3) and nitrites (NO_2) that can be used for growth by plants (Towle, 1989, p. 790). The nitrates and nitrites are absorbed from the soil and metabolized by plants. When animals consume the plants, nitrogen in the plants is metabolized by the animal. The nitrogen is then recycled back into the nitrogen cycle as animal wastes and dead organisms.

The fourth phase of the nitrogen cycle is the denitrification process by certain anaerobic bacteria. These types of bacteria break down nitrates (NO_3) and release nitrogen gas (N_2) back into the atmosphere (Towle, 1989, p. 790). Anaerobic, denitrifying bacteria can be found in both the soil and water.

The Riverside Regional Water Quality Treatment Plant utilizes both the natural nitrification and denitrification processes to control and remove unwanted nitrogen and ammonia compounds. In the secondary treatment phase aerobic bacteria and microorganisms are used to convert the ammonia compounds in the wastewater to nitrogen compounds that are metabolized by the microorganisms for growth and reproduction (J. Claus, personal communication, April 25, 1997). In the tertiary treatment of the wastewater almost all the nitrogen compounds (NO_2, NO_3) are metabolized or filtered out at the treatment plant. The nitrogen is further reduced through uptake by green plants and conversion to N_2 by bacteria living in and along the wetland ponds and channels of the Hidden Valley Wildlife Area.

<u>The Arundo</u>

A person cannot miss the presence of <u>Arundo donax</u>, a bamboo-like, non-native riparian plant species that can out-compete the native vegetation (City of Riverside, 1995, p. 2-4). It limits natural habitat for native animals, removes millions of gallons of water each day from the river, and becomes a fire hazard during the dry summer months. Several attempts to remove the arundo have been made and the most successful method to date has been to cut and spray the emerging shoots over a period of several months (J. Claus, personal communication, April 25, 1997). J. Claus also reported that, while effective, this method was tedious and required excessive work hours because most the work had to be accomplished by hand.

APPENDIX A

CURRICULUM FOR

TERTIARY WASTEWATER TREATMENT USING

RIPARIAN WETLANDS

USING THE CURRICULUM

An extensive amount of background information for teachers and students on the various aspects of the Hidden Valley Wildlife Area, wastewater treatment, and wetlands has been compiled in this project. For teachers to make the best use of the curriculum found in this appendix, they should be familiar with this background information. Teachers will find that without a thorough understanding and knowledge of these topics the lessons may lose their relevance and purpose.

Four introductory lessons are presented in this appendix. These lessons will provide the teacher with information such as the lesson summary, grade levels, subject areas, setting, duration, learning objectives, new vocabulary, background information, procedure, a materials list, student information sheets, and student activity sheets. The other suggested activities found with these four lessons are summarized for your convenience, and can be found listed under the environmental education curriculum guides, in the suggested activities section of this appendix.

Many of the lessons and activities presented in this project require the lesson or activity to take place in the out-of-doors, specifically in the Hidden Valley Wildlife Area. The following suggestions can maximize these outdoor experiences.

- Visit Hidden Valley wildlife Area prior to the activity to identify potential problems and potential teaching aids.
- Before visiting the outdoor site discuss appropriate outdoor behavior and possible consequences for inappropriate behavior.
- Discuss with students respect for natural areas and the plants and animals that live there. The Hidden Valley Wildlife Area has many poisonous plants and animals that demand caution and common sense be practiced.
- Clearly define the site boundaries and identify any special safety instructions such as the buddy system or emergency procedures.
- Use a whistle or other signaling device that can be heard by all students.
- Make the students aware of your expectations--they are here at Hidden Valley Wildlife Area to participate in a scholarly activity and complete the activity in the assigned time period.

LESSON ONE

Nitrogen Removal by Wetland Ponds

Lesson Summary:

This lesson introduces students to the nitrogen cycle, bacterial actions, and how people can use wetlands to help remove nitrogen and purify wastewater.

Grade Levels:

9^{th} through 12^{th}

Subject Areas:

Earth Science, Life Science, Math, Language Arts

Setting:

Classroom and Hidden Valley Wildlife Area

Duration:

Preparation - one hour
Activity - two hours

Learning Objectives:

Upon completion of this lesson students will be able to:

1) Test for nitrate and ammonia levels in wetland ponds.
2) Explain two advantages to using wetlands for wastewater reclamation.
3) Recognize the importance of wetlands in wastewater reclamation.

New Vocabulary:

amino acids: one of 20 different molecules consisting of carbon, hydrogen, oxygen, and nitrogen, that form proteins found in plants and animals.
ammonia: a hydride of nitrogen (NH_3), a toxic, colorless gas with a pungent odor.
ammonification: the process in the nitrogen cycle in which ammonia compounds form.
anaerobic bacteria: bacteria which do not require oxygen and can grow in the absence of oxygen
chlorine: a highly toxic element used in the purification (disinfection) of water.
denitrification: a final step in the nitrogen cycle, during which nitrogen gas is returned to the

atmosphere.

effluent: liquids or treated wastewater discharged from commercial, industrial, public, or agricultural operations such as a wastewater treatment plant.

influent: liquids or treated wastewater that flows into a commercial, industrial, public, or agricultural operation or a waterway.

nitrates: a group of chemicals (nitrogen-oxygen compounds) metabolized by plants for growth, found in fertilizer and animal wastes, can pollute groundwater sources, NO_3.

nitrites: a group of chemicals (nitrogen-oxygen compounds) metabolized by plants for growth, NO_2

nitrification: the process in the nitrogen cycle in which nitrates and nitrites are produced.

nitrogen: a naturally occurring element, constitutes 78% of the atmosphere, necessary for plant growth and formation of proteins in plants and animals.

nitrogen fixation: the process by which gaseous nitrogen in the air is converted into nitrates and nitrites.

pesticide: a chemical used to control pests such as insects or rodents.

ppm: the abbreviation for part per million.

Background Information for Teachers:

- See student information sheet

Materials:

- water samples from inflow and outflow of treatment ponds
- water samples from the Santa Ana River and Public Access Ponds
- "Dry-tab" type water testing kit for nitrite and ammonia, with 8 test tubes for each group of 2 to 4 students
- small containers to obtain water samples from water sources
- activity sheet
- information sheet

Procedure:

Warm Up:

Ask students to each create a list of what they believe they know about wastewater treatment and the nitrogen cycle. Tell the students to save this list until the end of the lesson so they can review and compare what they have learned from the lesson to the concepts or misconceptions in their lists.

Pass out the information sheets and have students read the background information about wastewater treatment and the nitrogen cycle. Review the diagrams of waste treatment plants and the nitrogen cycle. Discuss the filtering, settling, and treatment processes.

Ask the students:

1) Why must we treat wastewater?
2) Why can't we leave it all up to nature?
3) Are there pollutants that we can't see in water?
4) What is the source of the ammonium and nitrites in the water?

Discuss the role of the wetland ponds to help treat the wastewater.

Ask the students:

1) Is this the best method to remove excess nitrogen?
2) Do you think this process is harmful or beneficial to the wetlands?
3) Can you think of better ways to remove nitrogen from wastewater?
4) What role does nitrogen play in plant growth?

Activity: Beginning at the Nature Center

1) Divide students into small groups of 2 to 4 persons.
2) Give each group a test kit with 8 test tubes and 4 each, of the "dry-tabs", and the activity handout.
3) Review the activity sheet procedures with all students and demonstrate how to test a sample of water.
4) Direct each group to now begin the activity with the influent sample you have provided.
5) Lead the groups to the remaining three sites to collect and test the water.
6) Return to the Nature Center to finish the questions on the activity page. Groups are to answer the questions independently from each other and then they will share answers later.
7) Review together the results and activity answers of all the groups.

Evaluation:

- See activity sheet for evaluation of test results and reflective questions.
- Review student lists of initial concepts and compare these concepts with the new learning that has taken place during the lesson.

Suggested Follow-Up Activities:

1) Test for other water qualities such as hardness, taste, smell, pH, and turbidity.
2) Brainstorm activities that could reduce ammonia compounds, nitrites, and nitrates in wastewater.

References:

Madrazo, G. M., & Hounshell, P. B. (1990). Oceanography for Landlocked Classrooms. Reston, VA.: National Association of Biology Teachers.

Towle, Albert. (1989). Modern Biology. New York: Holt, Rinehart and Winston.

The Watercourse & Western Regional Environmental Education Council. (1995). Project WET Curriculum & Activity Guide. Bozeman, Montana: Author.

STUDENT INFORMATION SHEET
for
Hidden Valley Wastewater Treatment Ponds

The treatment of wastewater at the Riverside Regional Wastewater Quality Treatment Plant (RRWQTP) involves three phases which treat and purify wastewater. This reclaimed wastewater can be used again for purposes such as drinking water, agricultural and domestic irrigation, and to maintain ecological balances such as the historical water flows in the Santa Ana River and Hidden Valley Wildlife Area (HVWA) wetlands.

The first phase (primary treatment) involves filtration, settling, and skimming procedures to remove about 45 to 50 percent of the pollutants. The second phase (secondary treatment) uses helpful microorganisms (bacteria) to remove 85 to 90 percent of the remaining pollutants. The remaining solids and microorganisms are separated from the wastewater in settling tanks. The wastewater is further treated with disinfectants (chlorine) to kill any remaining disease-causing organisms, and then released into the Santa Ana River.

This wastewater may still contain small amounts of undesirable materials or chemicals such as nitrites, nitrates, ammonia, phosphates, heavy metals, and pesticides. The RRWQTP has a third phase of treatment (tertiary treatment) to remove these pollutants, but this phase is an expensive system to build and operate.

The Riverside Water Quality Control Plant (RWQCP), operated by the City of Riverside, is less than a mile upstream from Hidden Valley Wildlife Area (HVWA) and uses the wetlands in HVWA to take advantage of the natural cleansing processes of wetlands--to decrease the nitrogen level in its wastewater effluent, in addition to the tertiary treatment at the RWQCP. The ponds that can be viewed from the bluff just upstream from the Hidden Valley Nature Center are used to reduce the nitrogen level in the wastewater effluent before it is released into the river. Not only is this a natural way to clean the water but it is very cost effective and economical method that benefits the wetlands too.

To understand how wetlands and ponds work to lower the nitrogen levels in wastewater we need to understand the cycle of nitrogen in nature. The Nitrogen Cycle (refer to diagram) makes unusable nitrogen in the air available for use by plants and animals--to make proteins, build cells, live, grow, and reproduce. Atmospheric nitrogen is metabolized by nitrogen-fixing bacteria, in a process called nitrogen fixation, and converted from nitrogen gas (N_2) to ammonium compounds. These ammonium compounds are used by organisms and either remain as part of the organism when it dies or are released as animal wastes (human wastes). These wastes are broken down and a second process in the nitrogen cycle take place, called ammonification. In this process bacteria break down nitrogen containing amino acids from animals wastes and dead organisms to form ammonia compounds (NH_3). During a third phase called nitrification, bacteria oxidize ammonia compounds to produce nitrites (NO_2) and nitrates (NO_3). In the fourth and final part of the nitrogen cycle called denitrification, anaerobic bacteria break down nitrates, releasing them back into the atmosphere.

In the HVWA wetland ponds, the nitrite in the wastewater is converted by bacteria into nitrate, which is removed from the wastewater by plants. This occurs when the nitrates are either metabolized by plants such as algae and other pond plants for growth and reproduction, and/or converted by anaerobic bacteria back into nitrogen gas which returns to the atmosphere. These processes happen when the treated wastewater effluent flows through the ponds. The treated water then flows from the ponds into the Santa Ana River where it is used by cities downstream from Riverside to recharge their underground water supplies.

Nitrite and ammonia levels can be measured in water. These are toxic contaminants found in wastewater and their levels must be reduced before treated wastewater can be released. The upper ponds in the Hidden Valley Wildlife Reserve were constructed to help reduce these levels of nitrites, nitrates, and ammonia compounds through natural processes, before releasing the water into the Santa Anna River Watershed. You will be sampling and testing water from four different sources to determine if the ponds actually do reduce these toxic levels. Besides testing chemically you will also be looking at the water for algae and plant growth, which are signs of nitrates present in the water.

STUDENT ACTIVITY SHEET
for
Nitrogen Removal by Wetland Ponds

Introduction:

You will be testing four samples of water for nitrite and ammonia levels. You will obtain three of the four samples at different sites in the Hidden Valley Wildlife Area, the fourth sample will be provided by your instructor. These sites will be shown to you by your instructor. Test the samples and record your group's results on this sheet. Your results will be in **ppm** or parts per million.

Procedures:

1. Label your information chart with the following sites: 1) Upper Pond Inflow; 2) Upper Pond Outflow; 3) Santa Ana River; 4) Lower Pond.

2. Follow these steps at each water sampling site:
   a. Fill a clean test tube to the indicator line with the water to be tested.
   b. Remove one test tablet (for nitrite) or both a #1 and #2 (for ammonia) from the foil packages and add it to the water sample.
   c. Cap the test tube and shake it until the tablet(s) completely dissolve.
   d. Wait for the full color to form, 2 minutes for ammonia or 10 minutes for nitrite.
   e. Hold up the test tube against the white area of the color chart and compare the sample with the colors on the chart.
   f. Record the parts per million (ppm) on the activity page chart.

3. When all groups are finished your instructor will lead you back to the Nature Center where you will answer the questions on this sheet, based on your observations and results of the water tests.

Student Activity Sheet (2)

Sample	Site	Nitrite (ppm)	Ammonia (ppm)
1			
2			
3			
4			

Questions/Evaluation: if necessary, answer on separate sheet of paper and attach to this activity sheet

1) Which water sample showed the highest amounts of nitrites?

2) How does this compare with the other three samples?

3) Why do you think this sample tested higher than the others?

4) What was the difference between the nitrite levels of the pond inflow and outflow?

5) If you found a difference for #4, explain what you think may have caused this.

6) Which water sample showed the highest amounts of ammonia?

7) What was the difference between the ammonia levels of the pond inflow and outflow?

8) If you found a difference for #7, explain what you think may have caused this.

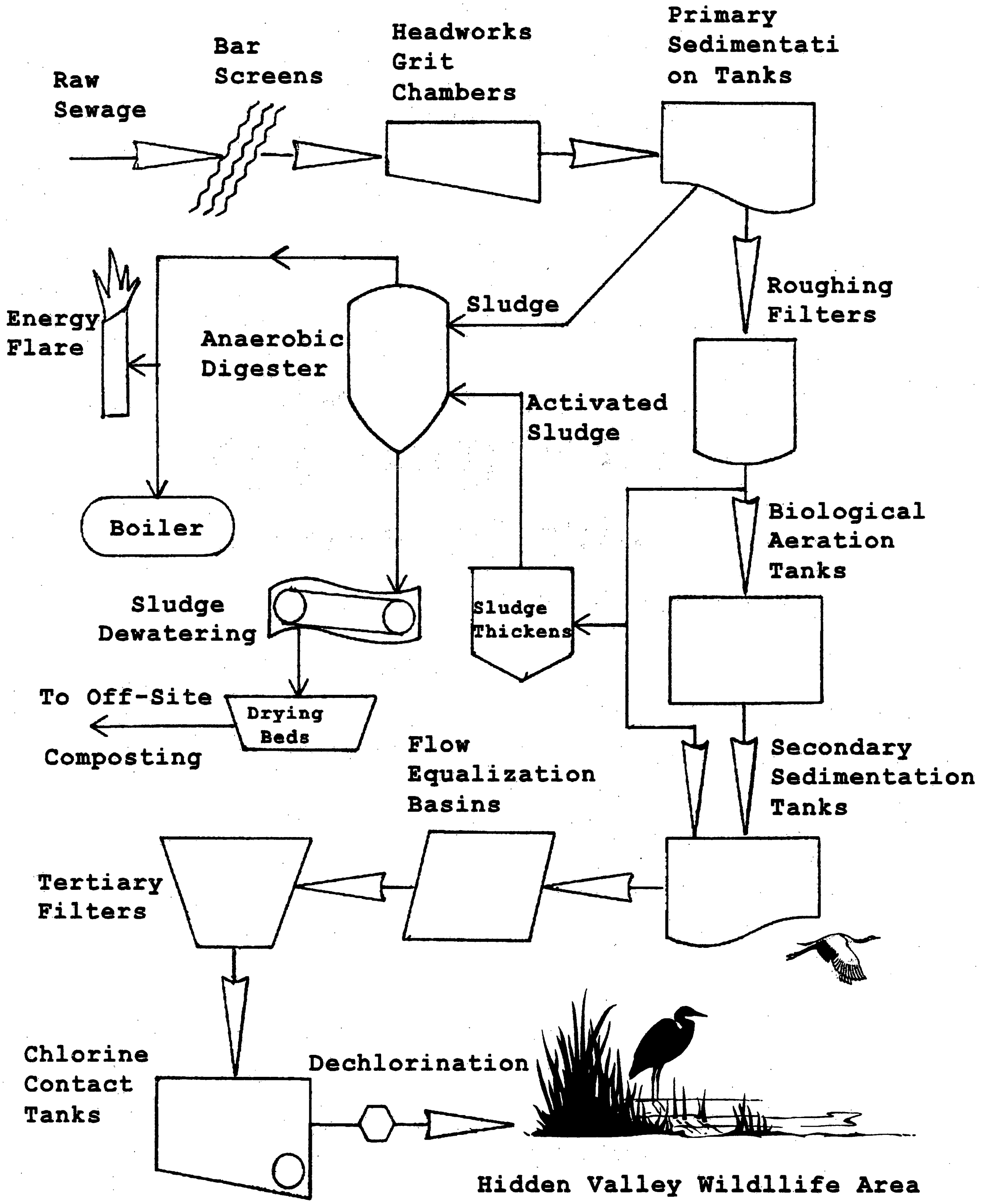
9) Why do you think quite a few cities can't or don't use the same treatment processes that Riverside does?

10) What do you think could be some long-term and short-term disadvantages to using wetlands for this purpose?

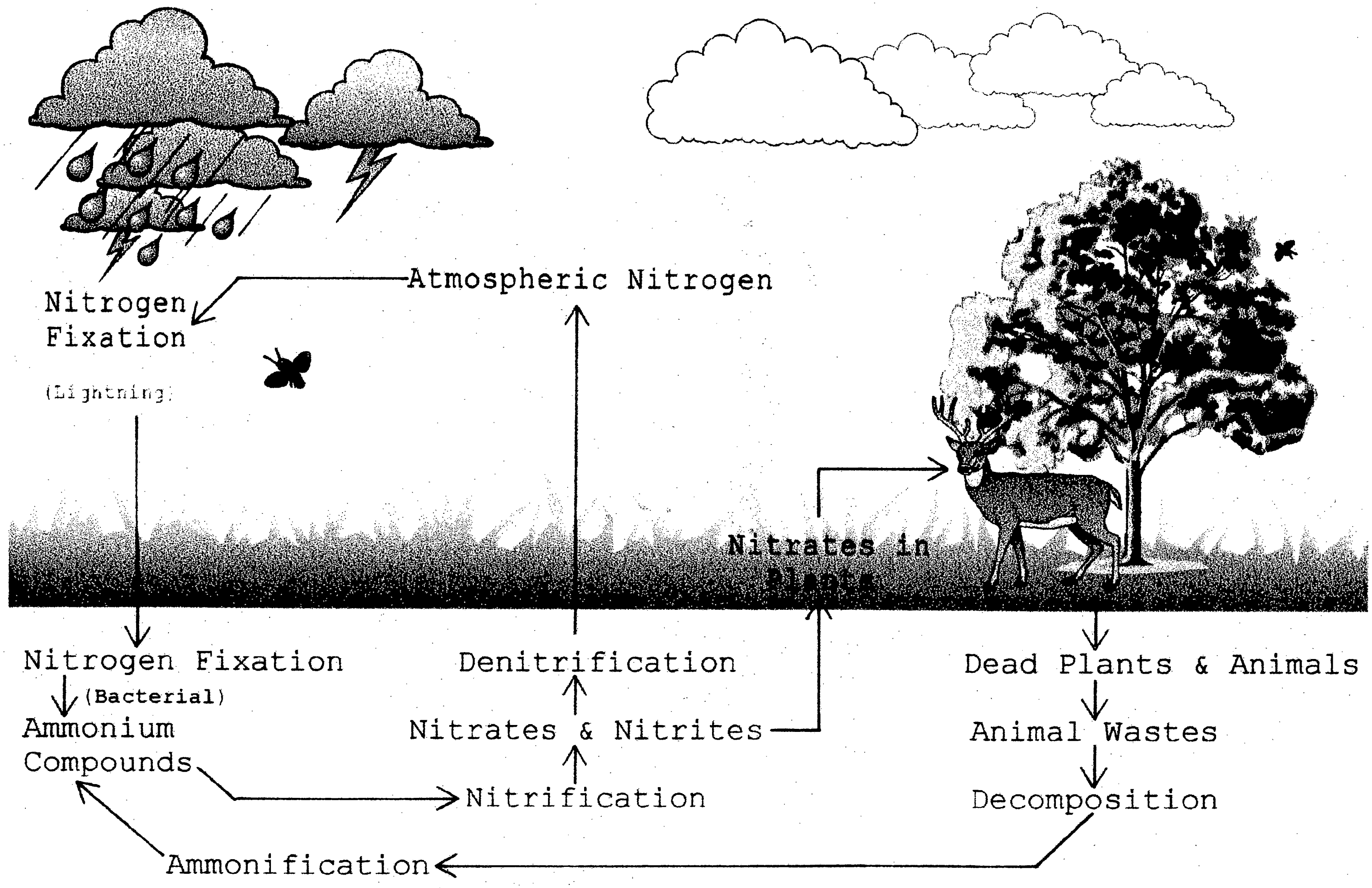
11) What do you think could be some long-term and short-term advantages to using wetlands for this purpose?

12) How important are wetlands for reclaiming wastewater?

TREATMENT PROCESSES
at the
RIVERSIDE REGIONAL WATER QUALITY TREATMENT PLANT



THE NITROGEN CYCLE



LESSON TWO

Using Duckweed to Measure Water Quality

Lesson Summary:

This lesson introduces students to indicator species and how they can be used to monitor water quality.

Grade Levels:

9th through 12th

Subject Areas:

Ecology, Life Science, Earth Science, Math, Language Arts

Setting:

Classroom

Duration:

Preparation - 30 minutes to one hour
Activity - 2 hours plus 10-20 minutes a day for four days

Learning Objectives:

Upon completion of this lesson students will be able to:

1) Test water quality using common duckweed.
2) Identify the importance of indicator species.
3) Explain the limitations of using indicator species to monitor water quality.

New Vocabulary:

bioassay: the use of a living organism to test the effects or presence of a substance.
effluent: liquid or dissolved waste discharged from commercial, industrial, or agricultural operations or treatment plants.
frond: a leaf structure of duckweed and some other plant species.
indicator species: a species of plant or animal which is used to monitor the health of an ecosystem.
point source contamination: pollution that comes from an identifiable source such as a water treatment plant.

Background Information for Teachers:

- See student information sheet.

Teacher Preparation:

You will need to collect materials and mix stock solution to be used in the activity. Many types of contaminants can be used for this activity including, coffee, soda, detergent, local pond water, herbicides such as 2,4-D or Roundup, etc. The following example uses detergent, but any contaminant can be substituted.

Making stock solution: Each student group need 100 ml of a 5% liquid detergent and 5 ml of nutrient solution. The solutions can be prepared as follows:

5% detergent solution- 5 ml (or grams) of detergent mixed with 95 ml of distilled water.

Nutrient solution- 1 T of Peter's fertilizer mixed with 1 gallon of distilled water.

The bottle construction and laboratory setup will take approximately two class periods. The first day will be spent cutting bottles and making dilutions and the second day will be spent setting up the experiment with the duckweed. It is recommended that you begin on a Friday and start the lab experiment on Monday to allow for 4 days of observations of the experiment.

When students count the duckweed fronds they need to count any protruding bud as a frond. You will probably need to demonstrate how to count the fronds to eliminate individual misinterpretations. Each member of a lab group should count each dish to ensure accuracy.

Materials: For each group (2-4 students)

- six 2-liter plastic soda bottles with caps
- distilled water
- 100 ml of 5% detergent solution
- 48 two-frond colonies of common duckweed species
- grease pencil or marking pen
- hand lens
- graph paper
- several pair of scissors
- labels or tape
- 10 ml graduated cylinder
- 100 ml graduated cylinder

- hot water or hair dryer
- student information sheet
- student activity sheet

Procedure:

Warm Up:

Ask the students:

1) Have you ever wondered how clean the water is that you drink or swim in?
2) What kinds of pollutants that we can't see might be in water?
3) How would you go about finding out if there is something harmful in water?
4) Can you suggest an experiment to detect harmful substances in water?

Pass out the student information sheet and have the students read about using duckweed as an indicator species.

Ask the students:

1) Have you ever seen duckweed? If yes, what does it look like?
2) Duckweed belongs to what group of living organisms?
3) What characteristics does duckweed have to make you think it's a plant?

Activity:

1) Divide students into groups of two or four persons each.

2) Direct students to follow the directions on their student information sheet and cut their bottles to make five observation dishes.

3) Direct students to correctly label their observation dishes as per their information sheet.

(Second day)

4) Students are to fill their observation dishes and obtain the correct dilutions by following the procedure in the student information sheet.

5) Once the dishes are ready students will place the duckweed into them.

6) Students will then place their dishes under a grow light or light source.

7) Each day for the next four days, students will observe their dishes with duckweed and note any changes.

8) On the fourth day students will graph their data and write their conclusions.

Evaluation:

- See activity sheet for evaluation of laboratory results and conclusions.

Suggested Follow-Up Activities:

1) Use *Daphnia* in a similar laboratory, compare the results.

References:

AgriScience Institute and Outreach Program. (1992). *Instructional Materials.* Washington, DC: Author.

STUDENT INFORMATION SHEET
for
Using Duckweed to Monitor Water Quality

Testing and monitoring of water is an expensive and labor intensive venture for government and private laboratories, as well as for high school laboratories. Recently common duckweed, Lemna minor, a small, floating aquatic plant that can be found all over the world has been added to the short list of indicator species.

An indicator species is a plant or animal that is sensitive to and responds specifically to conditions in a community or habitat. The presence, absence or condition of certain species in a particular habitat will indicate changes in the habitat such as pollution, over use, soil degradation, or other environmental problems.

There are currently four indicator species commonly used for freshwater environmental monitoring. These indicator species are Pimephales promaelas, Daphnia magna, Daphnia pulex, and Selenastrum capricornutum. Federal and state regulatory agencies, industries, and consulting laboratories routinely use these species to assay for water contamination. The Riverside Regional Water Quality Treatment Plant (RRWQTP) uses water fleas (Daphnia sp.), as an indicator species to monitor the effluent from the RRWQTP. They have been so successful with this monitoring process that the Santa Ana Regional Water Quality Control Board has asked other water treatment plants within their jurisdiction to follow suit and use Daphnia to monitor their effluent as well.

The Environmental Protection Agency (EPA), research institutions, and consulting labs are beginning to use duckweed as a fifth indicator species in the monitoring of effluents. Duckweed has also been used to monitor for hazardous chemicals and a duckweed test protocol has been published by the American Society of Testing and Materials.

Duckweed refers to a group of floating aquatic plants of the family Lemnaceae, and the common form of duckweed (Lemna minor) can be found worldwide. It is very easy to grow and use in the classroom, but remember that duckweed, like other indicator species, cannot measure the amount of contamination. It can only suggest the presence of contamination. Further investigation is required to determine the source and concentration. Duckweed plants are tiny, 2 mm to 4 mm in diameter, with a simple two-part structure of a frond and a root. They grow in colonies and through asexual reproduction reproduce and grow quickly, doubling in frond number every one to three days. Duckweed is very sensitive to herbicides and because it floats, is also susceptible to surface toxins (toxins that are not water soluble and form a layer of top of the water). Duckweed also has the ability to adapt quickly to new environments because of its high reproductive rate. This adaptive characteristic can interfere with test results if you attempt to test for contamination in the same water from which the duckweed has just been collected.

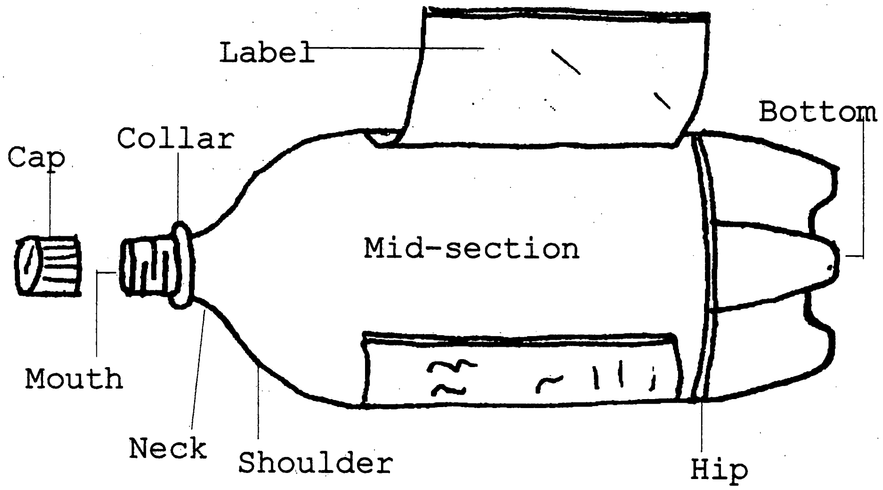
Cutting Plastic Bottles

You will need to cut five 2-liter plastic soda bottles to make your observation dishes and covers. To make the dishes follow these steps:

1) If your plastic bottle has no colored base then go to step 2, otherwise cut the colored base of the bottle to make a pedestal. Cut down through the colored plastic to about 1/4 inch above the bottom. Cut around the base until the excess is removed.

2) Cut through the clear plastic portion of the bottle about 1/4 inch below the shoulder and again about 1/4 inch below the hip of the bottle.

3) Discard the middle section in an appropriate receptacle for recycling or save it for other experiments.



STUDENT ACTIVITY SHEET
for
Using Duckweed to Monitor Water Quality

Introduction:

You will be testing the effects of four different concentrations of a contaminant on duckweed (Lemna sp.). To do this you will need to prepare five observation dishes, label them properly and place the correct amount of diluted contaminant in each dish. On completion of these steps you will place duckweed into each dish and place them in a growing area, checking and making observations about the duckweed on a daily basis. On the final day of the laboratory experiment you will graph the collected data and answer questions concerning the contaminant.

Procedure:

On Friday:

1) Cut five bottles using the directions given in the student information sheet to make five observation dishes.

2) Label the five observation dishes with your group name and the following:

A-Control	D-1 x 10^{-2}X
B-1X	E-1 x 10^{-3}X
C-1 x 10^{-1}X	F-1 x 10^{-4}X

On Monday:

3) Fill dish A with 90 ml distilled water. This is your control.

4) Fill dishes C, D, E, F with 90 ml distilled water.

5) Fill dish B with 100 ml of the 5% contaminant solution.

6) Take 10 ml of liquid from dish B, add to dish C and mix well.

   Note: it is important to completely rinse and drain the 10 ml graduated cylinder between dilutions.

7) Take 10 ml of liquid from dish C, add to dish D and mix well.

8) Take 10 ml of liquid from dish D, add to dish E and mix well.

9) Take 10 ml of liquid from dish E, add to dish F and mix well.

10) Take 10 ml of liquid from dish F and discard in the sink.

11) Add 5 ml of liquid fertilizer to all dishes.

12) Place eight two-frond colonies of duckweed into each dish and cover. Try to pick plants that are the same size.

14) Observe the dishes every 24 hours for three days and record the following: (a) total number of fronds, (b) any color changes, (c) any other changes in appearance, (d) general frond size in relation to the fronds in the control dish. Each group member should count the fronds in each dish.

15) After four days (96 hours), graph the data and write your conclusions.

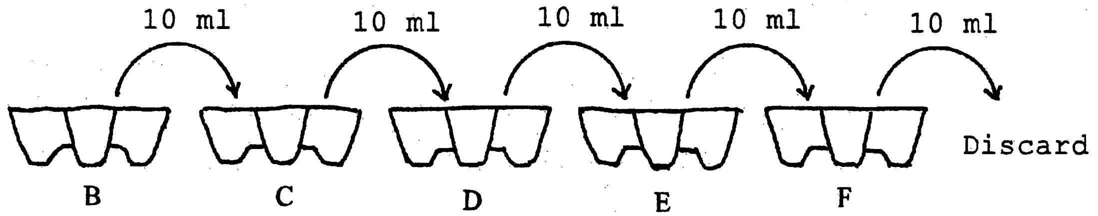
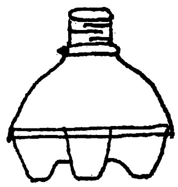
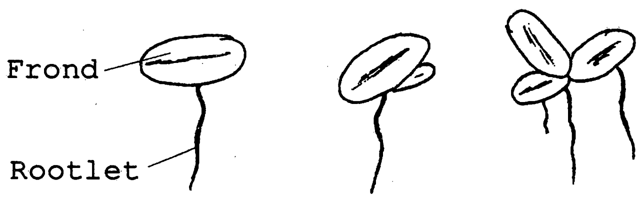


Diagram of dilutions



Dish with lid



Single-frond Plant

Two-frond plant with new bud

Triple-frond plant

STUDENT DATA SHEET
for
Using Duckweed to Monitor Water Quality

Day 1-Question: Does detergent affect the growth of duckweed? If so, could duckweed be used to assay for the presence of detergent in a water sample?

Predict: What do you expect to see happen to the duckweed colonies in the different concentrations? Which colonies do you expect to reproduce normally? Which colonies do you expect to reproduce more slowly, or die completely, if any?

Write your hypothesis:________________________________

____

____

____

Day 2-5: Record observation on the data tables.

Table 1: **Number of Duckweed Fronds**

Hours of Exposure

Dish	0	24	48	72	96
A					
B					
C					
D					
E					
F					

Table 2: Other Observations-changes in color, damage, frond size compared to frond size in control dish.

0 Hours:____

____

____

24 Hours:____

____

____

STUDENT DATA SHEET (continued)
for
Using Duckweed to Monitor Water Quality

48 Hours: ____

____

____

72 Hours: ____

____

____

96 Hours: ____

____

____

Conclusions: ____

____

____

Results and Discussion:

1) Did your data support your hypothesis?

2) Were there any dishes with results which surprised you? Which ones and why?

3) List at least one question that these results lead to.

4) Design an experiment that could be used to answer your question from #3.

LESSON THREE

Is This a Wetland?

Lesson Summary:

This lesson introduces students to the plant life and animal life found in the Hidden Valley Wildlife Area. Wetlands can be identified by the types of vegetation, soils, wildlife, and amount of water present.

Grade Levels:

9th through 12th

Subject Areas:

Earth Science, Life Science, Math, Language Arts

Setting:

Hidden Valley Wildlife Area

Duration:

Preparation - 30 minutes to one hour
Activity - one to two hours

Learning Objectives:

Upon completion of this lesson students will be able to:

1) Construct a transect to study specific areas.
2) Identify and list common plant and animal species found in Hidden Valley Wildlife Area.
3) Describe the major characteristics of a wetland habitat.
5) Determine the location of wetland areas.

New Vocabulary:

acidic: referring to a substance or solution with a pH value lower than 7.
anaerobic: an organism, process, or condition that requires the absence of oxygen.
emergents: amphibious plants with the ability to grow partially in and out of water.
estuarine: refers to a costal saltwater ecosystem.
floaters: are plants that float freely on the water surface or with leaves that extend to the surface.
hydric: referring to having to do with water.
hydrophytic: refers to organisms that need or can tolerate water.

marsh: an area of land typically wet, low lying, with hydrophytic, herbaceous species of plants.
palustrine: inland freshwater systems such as rivers, ponds, lakes, marshes, and swamps.
photosynthesis: the process by which green plants convert light energy into stored chemical energy (sugars).
submergents: plants that live solely underwater.
swamp: an area of land typically wet, low lying, with hydrophytic, hardwood species of plants.
tidal flats: areas of coastal land that are periodically covered with ocean water due to tidal influences.
wetland: areas with water-logged, hydric soils, and hydrophytic vegetation.

Background Information for Teachers:

- See student information sheet.

Materials:

- Field Guides to wetland plants and animals
- four 2-ft wooden stakes
- 50-ft of string or clothesline
- 25-ft measuring tape, 12-inch ruler
- hand lens
- small containers to hold insects or other small animals
- student information sheet
- student activity sheets

Procedure:

Warm up:

Ask students:

1) What kinds of plant and animals do you think you might find in a wetland?
2) Do you think wetland areas have different kinds of plants, animals, and soils than non-wetland areas?
3) What kinds of things would you look for when trying to determine if an area is truly a wetland?

Activity:

1) Divide students into groups of two or three persons each.
2) Review the student information sheet and

student activity sheet with students.
3) Define a general area for students to set up their transects.
4) Direct students to construct a transect and survey for flora and fauna within its boundaries.
5) Students are to record the findings of their surveys.
6) When surveys are completed, students are to interpret their data and determine if Hidden Valley Wildlife Area is a wetland.
9) Students will finish the activity by answering the question of the student activity sheet.

Evaluation:

- See activity sheet for evaluation of activity results and conclusions.

Suggested Follow-Up Activities:

1) Visit other habitat or ecosystems.

References:

Hess, G. S., Capps, W., & Burkhalter, L. (1996). Introduction to environmental science. In R. B. Birkenholz & B. G. Garton (Eds.), Applied environmental science. Washington, DC: National Council for Agricultural Education.

American Forest Foundation. (1994). Project learning tree environmental education activity guide. Washington, DC: Author.

Western Regional Environmental Education Council. (1992). Project wild Aquatic. Bethesda, MD: Author.

STUDENT INFORMATION SHEET
for
Is This a Wetland?

Wetlands are typified by areas with water-logged soils or standing water that remains for prolonged periods during the year. The water sources for these wetlands can vary from rivers, streams, lakes, and ponds to agricultural runoff, wastewater discharge, and the ocean.

The United States Fish and Wildlife Service defines a wetland in terms of the type of habitat that can be found in the transition between upland and aquatic environments, where the water level is just beneath, at, or slightly above the surface of the soil. The federal government's definition of wetlands is areas that are covered or saturated by water for a length of time long enough to support vegetation that can tolerate or requires wet or saturated soil conditions.

For the purpose of defining a wetland the Santa Ana Regional Water Quality Control Board, the agency responsible for protecting all wetlands in the Santa Ana River Basin, acknowledges three general characteristics of wetlands: hydrophytic vegetation, hydric soils, and wetland hydrology. Wetlands are classified by scientists and government agencies into two major types, estuarine and palustrine, based upon the characteristics of the water, soils, types of vegetation, and location or proximity to water. Water is the major criteria for classifying wetlands and includes inland freshwater (palustrine) systems such as rivers, streams, lakes, ponds, marshes, and swamps that constitute 90% or 97.8 million acres of remaining wetlands in the United States. Wetlands are also found in coastal saltwater (estuarine) systems that include saltwater marshes, mangrove swamps, and tidal flats that comprise the 5.5 million remaining acres of coastal wetlands in the United States.

Wetland soils are classified as hydric soils. These soils are oxygen-depleted due to the prolonged periods of water saturation. The soils commonly found in wetland areas can be high in organic matter resulting from the decay of plants and animals or high in mineral content of sands, silts, and clays. The organic soils tend to be more acidic and darker in color than the purely mineral soil types but both provide an anaerobic environment due to the prolonged presence of water, and act as a storage reservoir for water.

The vegetation found in wetland areas can vary greatly depending upon the amount, duration, and quality of water and the type of soils present. Wetland vegetation can be classified as hydrophytic or "water loving" plants that can tolerate or require long periods of contact with water or water saturated soils. These aquatic plants are divided into three groups: emergents, floaters, and submergents. Emergent plants are amphibious, with the ability to grow with their lower portions submerged in water while their upper portion is out of the water. Cattails and reeds are a common example of emergent wetland vegetation. Plants that float freely on the water surface or are rooted on the bottom with leaves extending to the surface are classified as floaters. The water hyacinth is a very common floater in wetland areas.

The third group of wetland plants are classified as submergents because they live solely underwater. Their plant structure is different from terrestrial plants, and this enables submergents to directly absorb nutrients, water, and gasses for photosynthesis directly from the water through small, thin leaves. The different types of wetlands--marshes, ponds, rivers, swamps, and tidal flats--are home to a variety of different wetland plants that can grow only in a specific type of wetland. Marshes are home to plants that are typically herbaceous or "soft-stemmed." Such plants include water lilies, cattails, grasses, and sedges. In swamps, river flood plains, and streams the dominant plants are woody-stemmed plants including hardwood trees such as willows, cottonwoods, maples, and alders.

Hidden Valley is home to 47 families of flora (plants) that include 167 different species. For a complete listing of plant species, see the list after the lesson.

Animal species are abundant in the Hidden Valley Wildlife Area. There are 31 identified insect families representing nine insect orders, ten species of fish, five species of amphibians, and 16 species of reptiles including geckos, snakes, skinks, and lizards. In terms of mammals found in Hidden Valley Wildlife Area, there are 44 species of mammals representing 18 different mammal families. Although already a long list of animals, the most abundant group of animals are the 94 species of birds and waterfowl that call Hidden Valley Wildlife Area their home for all or part of the year. For a complete listing of animals, see the list after the lesson.

STUDENT ACTIVITY SHEET
for
Is This a Wetland?

Introduction:

You will be surveying a portion of the Hidden Valley Wildlife Area to collect data on overall conditions, plants and animals found there. Using this data you will determine if Hidden Valley Wildlife Area can be considered a wetland.

Procedure:

1) Set up your survey area. It should measure approximately 100 square feet. To do this you can drive four stakes into the ground making sure they are a right angles to each other (forming a square), and 10 feet apart. Tie a string or clothesline between the stakes to define your survey area.
2) Record a general description of your surroundings, including geographic location, flora and fauna, presence of water, source of water, and overall conditions or the area.
3) Starting in a corner of your plot, begin to carefully observe and identify the plants and animals within your area. Use field guides and manuals and your instructor as references to help you identify what you find.
4) Record your findings on the activity sheet.
5) Answer the questions on the activity sheet.

General Description:____

____

____

____

Questions/Evaluation:

1) How many species did you expect to find? How many did you find?
2) Can any of the plant species you found be considered hydrophytes (water loving)? If yes, how many? Which ones?
3) Can any of the animal species you found be considered wetland species? If yes, how many? Which ones?
4) Make a list of the characteristics you would expect in plant and animals that can be found in wetlands.

5) Is the area in and around your survey plot a wetland? Why or why not, explain?

Species List

Check one

Name of species	**Plant**	**Mammal**	**Reptile**	**Amphibian**	**Bird**

LESSON FOUR

Debating Issues: Using Wetlands to Clean Wastewater

Lesson Summary:

This lesson introduces students to using debate to develop, communicate, and defend their ideas and positions concerning the environment.

Grade Levels:

9th through 12th

Subject Areas:

Social Studies, Environmental Studies, Language Arts, Science.

Setting:

The classroom

Duration:

Preparation - one hour
Activity - one to two hours

Learning Objectives:

Upon completion of this lesson students will be able to:

1) Identify a local land-use issue.
2) Develop a clear, logical debate.
3) Communicate their ideas and positions through debate.
4) Evaluate their own and other students' debate.

Background Information for Teachers:

- See student information sheet

Materials:

- student information sheet
- student activity sheet
- debate score card

Procedure:

Warm Up:

Ask the students:

1) How are important decisions made?
   -discuss various decision making processes.
2) What is Arundo? Is it helpful or harmful?

3) How would you prepare yourself to debate an issue?
4) Pass out the student information sheet and have the students read it.
5) Distribute the student activity sheet and explain to the students how to score each other's debate.

Activity:

1) The instructor should be the moderator to lead the debate. One team member will speak at a time and a team member must receive permission from the moderator before speaking. The moderator will call once on each team for each round.
2) Students should be divided equally into four or six teams of five to six individuals each.
3) Half the teams represent the affirmative, supporting the debate statement, and the second half of the teams represent the negative, opposing the debate statement.
4) All teams must address the ILL, BLAME, CURE, and COSTS of their stance.
5) The instructor will direct the student teams to develop clear, logical arguments for debate using information from previous classroom lessons, textbooks, references, and other sources. Instructor should give teams at least one class hour for this portion of the activity plus assign information gathering as a homework assignment.
6) If possible arrange the seating (desks) in the room with one row for each team (four teams = four rows).
7) Each team will begin with their opening statement (either positive or negative), given by one member of the team, and should consist of ILL, Blame, and Cure.
8) As other team members are called upon in successive rounds they are to debate other aspects of the issue or make a rebuttal to another team's debate.
9) Debate for each team member should be limited to two minutes.
10) Each student will score the debates of other students, awarding one to five points and recording this score on the debate scorecard.

Evaluation:

1) Ask students to write what they found to be the most difficult during the activity and why.
2) Have the students tabulate the team scores from all student worksheets to determine which team and which position scored the highest. Ask the students why they believe this team scored so well?
3) Ask students to make a list of the traits of a good debate and things they might do to improve their own debate.
4) Ask the students to share their lists. Lead a class discussion on how students can improve their arguments.

Suggested Follow-Up Activities:

1) Use other local issues for debate topics.

References:

Hess, G. (1996). Land uses, regulations, and ordinances. In R. B. Birkenholz & B. G. Garton (Eds.), Applied Environmental Science. Washington, DC: National Council for Agricultural Education.

California Agriculture Teachers Association. (1996). CATA Curricular Code. San Luis Obispo, CA: Author.

STUDENT INFORMATION SHEET
for
Debating Issues: Using Wetlands to Clean Wastewater

A person cannot miss the presence of Arundo donax, a bamboo-like, non-native riparian plant species that can out-compete the native vegetation at Hidden Valley Wildlife Area (HVWA). It limits natural habitat for native animals, removes millions of gallons of water each day from the river, and becomes a fire hazard during the dry summer months. Several attempts to remove Arundo have been made and the most successful method to date has been to cut and spray the emerging shoots over a period of several months. While effective, this method is tedious and requires excessive work hours because most the work has to be accomplished by hand.

The Wetland Enhancement Project (WEP) has the objective of restoration and improvement of the existing wetlands in the HVWA to maximize their use for "polishing" the effluent from the Riverside Regional Water Quality Treatment Plant while enhancing the wetland environment.

On completion of the WEP the City of Riverside expects several benefits to the project. These benefits include (a) denitrification of effluent from the Riverside Water Quality Control Plant; (b) restoration of high-quality riparian habitat; (c) groundwater recharge; (d) improved public day use areas and nature center; (e) improved management of the HVWA; (f) a consistent water source; and (g) increased opportunities for scientific research, development, and public education.

The WEP was completed through a variety of enhancement projects that include ensuring adequate water flow, plant growth, open water areas, water percolation, Arundo removal, and conversion of farmland into productive wetland ponds.

The Issue:

Some ecologists have recommended that Arundo be eliminated from the riparian zone in the Hidden Valley Wildlife Area (HVWA). They argue that Arundo has overtaken and crowded out the native plant species, eliminating native habitat and thus, reducing native species of animals, birds, amphibians, and reptiles.

Other ecologists and the City of Anaheim argue against the removal of Arundo. They are concerned that the chemicals used in Arundo removal will remain in the water and pollute their drinking water supplies.

Public agencies also support the elimination of Arundo because it absorbs and removes millions of gallons of water each day from the river--water destined for aquifers downstream that are used by cities in Orange County. Other groups including a local native plant association and the local Audubon Society support Arundo removal. They argue that native plants and animals are losing habitat and their position in the environment. They also argue that the infestation of Arundo removes excessive amounts of water from the river causing detrimental effects to native flora and fauna.

All the wetland area involved in this issue is located in the same regional boundaries controlled by the Santa Ana Regional Water Quality Control Board. The Board is holding a hearing on the topic of removing Arundo from the wetlands in the HVWA. This proposal is called Arundo Removal in the Hidden Valley Wildlife Area.

For this debate your team will need to address the following areas concerning the topic of Arundo removal.

Ill asks the question, "What are the significant problems, harms or ills within the present system." For those in favor of change, the ill would be arguments suggesting the existing way of doing things results in serious problems or does not achieve certain goals. For the defender of the present system, the ill becomes a place to look for arguments to deny the existence of harms or to minimize their significance.

Blame asks the question, "Is the present system responsible for the existence of the ills?" The "advocate of change" needs to identify characteristics of the present policy and demonstrate the ways in which they are related to the ills of that policy. The "opponent of change" needs to seek to deny that characteristics of the present policy are related to the ills and suggest minor repairs to the policy.

Cure asks the question "Will the proposed change remove the ills of the present system?" Both proponents and opponents should look for arguments that suggest that change in the policy will or will not achieve its stated or implied objectives.

Cost asks the question,"Are the disadvantages of the proposed change significant?" The advocate of change should be prepared to demonstrate that the disadvantages of the proposed change are not so great as to outweigh any benefits. The opponent should be able to point out the excessive social or material costs outweigh the benefits.

STUDENT ACTIVITY SHEET

for

Debating Issues: Using Wetlands for Cleaning Wastewater

Introduction:

You will be debating an issue concerning the removal of a plant species called Arundo. You will be part of a team that will argue either in favor of against this proposal. Using textbooks and other reference sources you and your team will develop clear, logical arguments to use in the debate. Your debate will be scored and you will have a chance to score the debate of other students.

Procedure:

1) After your instructor has assigned you to a team, your team will be assigned to an organization representing a position either in favor or against the topic.
2) You and your team will be given time to identify and develop your arguments for debate. These should include arguments concerning the ILL, BLAME, CURE, and COST concerning the issue. You may use any and all resources available to you.
3) During the debate you will be given at least one chance to debate your point. You must first be recognized by the moderator and then stand and give your name and organization you represent before beginning your debate.
4) As other students debate their points you are to score their argument and record it on the debate scorecard.
5) After all debate has finished total the points on the scorecard.

Guidelines for Scoring the Debate

Scores will be awarded from 1-point to 5-points based upon the following criteria:

- The topic is well defined, clearly stated, supported by evidence, well organized, and uses sound, logical reasoning.
- The ILL, BLAME, CURE, and COST are given and evidenced.
- The statements in the debate demonstrate knowledge of the subject and showed evidence of preparation.

STUDENT ACTIVITY SHEET (continued)

Debate Scorecard

STUDENT NAME	TEAMS 1	2	3	4	5	6	TEAM TOTAL

SUGGESTED LESSONS AND ACTIVITIES
for
Tertiary Wastewater Treatment Using Riparian Wetlands

The following list of lessons and activities can be used to supplement, integrate, or expand the four lessons found in the previous section. The list includes a brief summary of the lesson or activity and the related wetland/wastewater topic or topics such as wetlands, soils, animals and plants, water, habitat, wastewater, and environmental issues. The activities and lessons are found listed under their respective source.

Project WILD

Western Regional Environmental Education Council. (1992). Project WILD. Bethesda, MD: Author.

Habitat Rummy: page 40, Habitat.
Students learn to identify the components of habitats such as food, water, and shelter, and apply their knowledge to specific species as part of a game.

Habitrekking: page 56, Habitat.
Through observation, students investigate, gather data, prepare, and present their observations of a habitat.

Wild Words...A Journal Making Activity: page 66, Habitat.
In this activity students design and create their own journals and use them to record observations in out-of-door settings.

Environmental Barometer: page 80, Habitat.
Students observe and count wildlife in two or more areas and compare the results. Students discuss the differences and consider how wildlife can be used as an indicator of environmental quality.

How Many Bears Can Live In This Forest?: page 134, Habitat.
Through a game where students become "bears" to search for major components of their habitat, the students learn about the components of habitats and limiting factors of habitats.

Oh Deer!: page 146, habitat.
Students become "deer" in this activity to learn the three essentials of a habitat; food, water, and shelter.

Students will also learn about limiting factors of a habitat.

__**Riparian Zone:**__ page 206, Environmental Issues.
Students learn about land-use planning and decision making in this activity by simulating a Board of Commissioners hearing. Students represent the various interests groups that are part of the board. Students will also evaluate the possible consequences where land-use planning does not take place.

__**To Zone Or Not To Zone:**__ page 266, Environmental Issues.
This activity is very similar to Riparian Zone, with students role-playing the parts of a County Commission deciding a land-use issue. Through this activity students will be able to describe the importance of land-use planning.

__Project WET__

The Watercourse & Western Regional Environmental Education Council. (1995). __Project WET.__ Bozeman, MT: Author.

__**Thirsty Plants:**__ page 116, Water.
Students learn about the water cycle and transpiration in plants through a teacher demonstration and a student activity with plants. Students will be able to explain transpiration and describe the importance of plants in the water cycle.

__**The Incredible Journey:**__ page 161, Water.
In this water cycle game, students simulate the movement of water in the water cycle. Students will learn about water movement in the water cycle and the states of water as it moves through the water cycle.

__**Wetland Soils In Living Color:**__ page 212, Soils and Wetlands.
Students make a soil color chart in the activity and use it to classify soil types. Students also learn the conditions that create wetland soils.

__**Color Me A Watershed:**__ page 223, Water.
Students interpret maps to observe how development will affect a watershed. Students also learn to recognize how population growth causes changes in land use and how these changes affect water runoff.

A Drop In The Bucket: page 238, Water.
In this activity students calculate the percentage of fresh water available for human use and learn why water is a limited resource.

Sparkling Water: page 348, Water.
In this activity students will learn about the processes for testing wastewater as they are asked to devise a method to remove contaminants from wastewater.

What's Happening?: page 425, Water.
Students develop, conduct, and interpret the results of a survey on a selected water resource issue. Students discuss how the survey is used to determine policies.

Aquatic Project Wild

Western Regional Environmental Education Council. (1992). Aquatic project WILD. Bethesda, MD: Author.

How Wet Is Our Planet?: page 8, Water.
In this activity students learn about the amount and distribution of water on, in, and above the earth's surface. Students calculate water volumes using percentages.

Water Canaries: page 38, Habitat, Water, Animals and Plants.
Students assess the environmental quality of a stream or pond, using indicators such as pH, water temperature, and the presence of organisms, through various observation and testing procedures. Students are to identify and draw organisms and record their observations.

Wetland Metaphors: page 54, Wetlands.
Students learn to describe the characteristics of wetlands and demonstrate their understanding of the importance of wetlands through the use of metaphors.

Blue Ribbon Niche: page 72, Habitat.
Students create an art form to represent an organism found at an outdoor site. Students will research information on the organism prior to visiting the site and share this information with each other during their visit.

Project Learning Tree

American Forest Foundation. (1994). Project learning tree environmental education activity guide. Washington, DC: Author.

400-Acre Wood: page 169, Environmental Issues.

This activity has students playing the roles of managers of a 400-acre public forest. Students must make management decisions and will experience the analysis and decision making process related to forest management.

Watch On Wetlands: page 258, Environmental Issues.

Students learn about the characteristics and types of wetlands before "adopting" a wetland for in-depth study. Students are presented with three wetland issues to analyze and make land-use decisions upon.

WOW!:The Wonders Of Wetlands

Slattery, B. E. (1993). Wow!:The wonder of wetlands. Baltimore, MD: DeVilbiss Printing.

Wetland Weirdos: page 26, Wetlands.

In this activity students study adaptations of plants and animals in wetlands. Through the investigation of cattails and beavers, students formulate questions and answers about wetland adaptations and behaviors.

Wet'n'Wild: page 29, Habitat, Wetlands.

Students visit a wetland to investigate the wetland habitat and what lives in it. Students will construct a field guide to record their observations and animals they collect.

Water We Have Here?: page 68, Water, Wastewater.

While in the field, students measure and record water quality indicators such as pH, temperature, salinity, turbidity, dissolved oxygen, and flow rate. Students then interpret the data and determine water quality.

Do You Dig Wetland Soil?: page 110, Soil, Wetlands.

In this activity students sample soils and record their observations of soil textures, moisture, particle size, and color, before determining the soil types using a soil texture key.

Always A River:

U.S. Environmental Protection Agency. (1991). Always a river. Cincinnati, OH: Author.

Wetlands Trivia: page 43, Wetlands, Soils, Water.

In this lesson students will research for information on wetlands, their significance, and threats facing them. Using the format of a game, students will test their knowledge of wetlands.

Wetlands Safari: page 71, Wetlands, Animals and Plants.

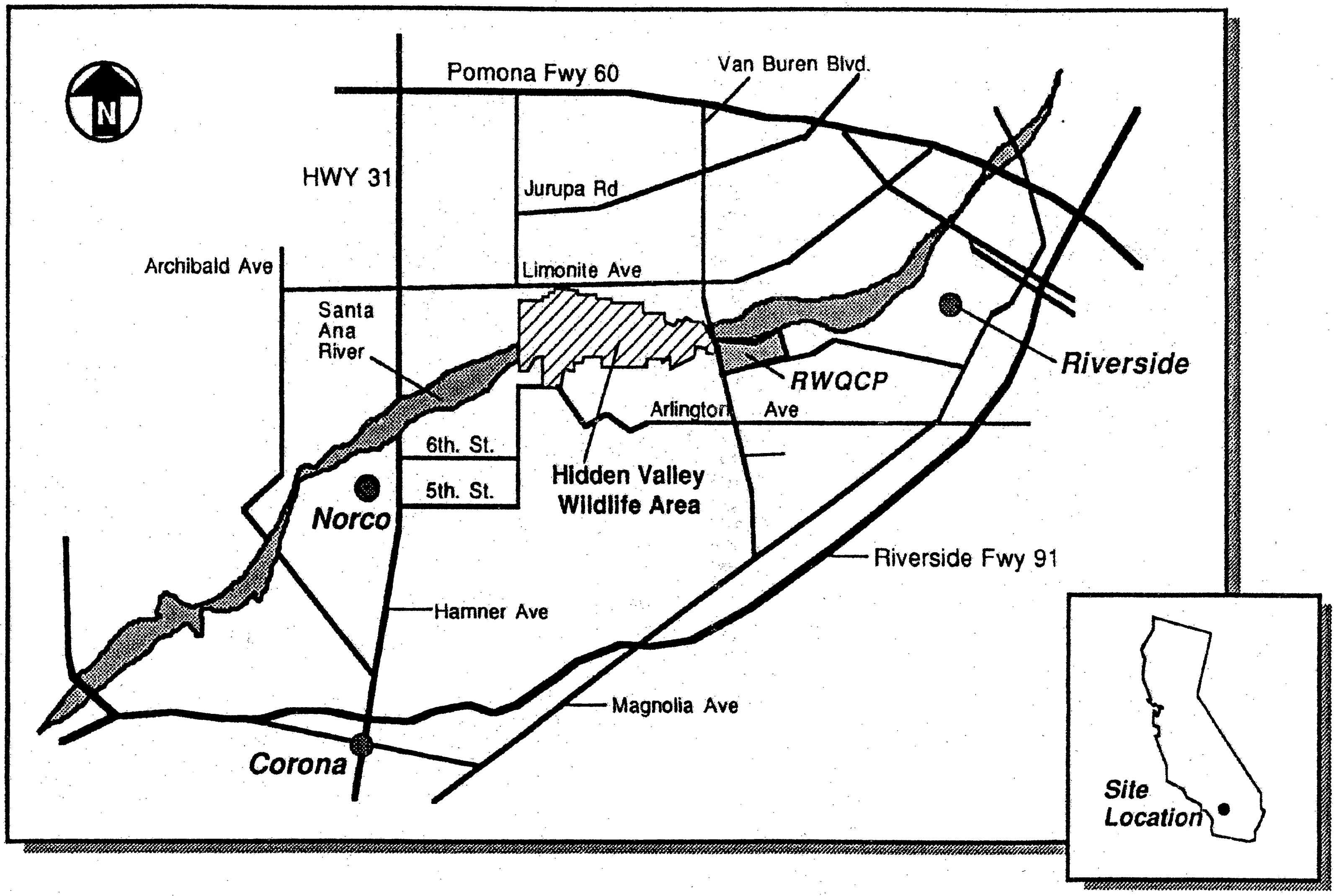
While visiting a wetland, students will make a survey of animals and plants observed during the visit. Students will analyze the survey and discuss plant and animal populations based on their observations.

Planning For The Future: page 205, Environmental Issues, Habitat.

In this activity students will learn to balance economic needs with environmental concerns by planning their own community--making decisions on locations of community developments within several habitats. Students then must explain their decisions.

APPENDIX B

MAPS AND DATA CHARTS


N
Pomona Fwy 60
Van Buren Blvd.
HWY 31
Jurupa Rd
Archibald Ave
Limonite Ave
Santa Ana River
RWQCP
Riverside
Arlington Ave
6th. St.
5th. St.
Hidden Valley Wildlife Area
Norco
Riverside Fwy 91
Hamner Ave
Magnolia Ave
Corona
Site Location

Hidden Valley Operations
Summary Sheet

	Jan-96	Feb-96	Mar-96	Apr-96	May-96	Jun-96	Jul-96	Aug-96	Sep-96	Oct-96	Nov-96	Dec-96	AVERAGE
Flow (mgd)													
Influent	7.67	5.77	8.21	12.30	12.00	13.40	14.30	14.19	13.31	13.07	10.62	11.03	11.32
Effluent (surface flow)	6.47	4.41	5.21	9.10	7.95	8.72	8.44	8.23	9.13	8.23	6.28	6.59	7.40
Effluent (sub-surface flow)	1.16	1.29	2.92	2.89	3.72	4.27	5.42	5.56	3.87	4.61	4.21	4.07	3.67
Evapotranspiration	0.04	0.07	0.08	0.31	0.33	0.41	0.44	0.4	0.31	0.23	0.13	0.37	0.26
Average Percolation Rate	15%	22%	36%	23%	31%	32%	38%	39%	29%	35%	40%	37%	31%
TIN Concentration (mg/L)													
Influent	13.6	15.7	16.1	16.5	13.3	14.3	15.4	13.0	14.0	13.1	11.9	11.5	14.03
Effluent (surface flow)	8.30	6.70	6.20	10.40	7.30	8.00	8.80	8.20	8.30	8.10	7.40	5.70	7.78
Effluent (sub-surface flow @ 8" depth)	1.85	2.25	1.71	3.20	3.80	3.10	4.16	3.31	3.92	2.89			3.02
Effluent (sub-surface flow @ 24" depth)	1.30	1.55	1.42	2.30	3.20	2.10	2.98	2.93	3.45	1.93	3.76	4.70	2.64
Effluent (Combined, Flow-Weighted, Hidden Valley)	7.4	5.7	4.5	8.5	6.0	6.0	6.5	6.0	6.9	5.9	5.9	5.3	6.22
Total System (RWQCP & wetlands)	11.5	14.4	13.4	14.2	11.4	12.2	10.6	10.8	11.5	9.8	10.8	9.9	11.71
TIN Removal (%) - by Concentration													
Surface Removal	39%	57%	61%	37%	45%	44%	43%	37%	41%	38%	38%	50%	44%
Sub-surface Removal	90%	90%	91%	86%	76%	85%	81%	77%	75%	85%	68%	59%	80%
TIN Removal (%) - Flow Weighted													
Surface Removal	39%	57%	61%	37%	45%	44%	43%	37%	41%	38%	38%	50%	44%
Sub-surface Removal	8%	8%	11%	13%	11%	15%	16%	18%	11%	18%	13%	5%	12%
Overall (surface and sub-surface)	47%	65%	72%	50%	56%	59%	59%	55%	52%	56%	51%	55%	56%
Water Temperature (degree C)													
Influent	18.0	20.9	20.6	22.5	24.2	25.4	26.5	27.1	26.3	24.0	20.2	19.[illegible]	22.95

Hidden Valley Wetland Ponds Data Summary						
Pond No.	**Feature/Configuration**	**Water Depth (ft)**	**Surface Area (acres)**	**Volume (MG)**	**Residence Time (days)**	**Average Effluent TIN (mg/L)**
1	Deep pond, feeds #2 and #3 ponds; no vegetation.	5.0	0.54	0.88	0.5	13.3
2	Test pond parallel to #3 pond; planted with bulrush only.	2.5	1.21	0.98	1.0	11.3
3	Test pond parallel to #2 pond; planted with cattails only.	2.5	1.35	1.10	1.0	11.4
4	Test pond; 2 deep zones and 1 shallow zone; mixed wetland vegetation planted in shallow zone.	5.0 2.0	5.15	5.74	3.0	8.2
1-4	Pond system including pond #1 through pond #4.		8.25	8.70	5.5	8.3
5	Test pond; 3 deep zones and 2 shallow zones; mixed wetlands vegetation in the shallow zone.	5.0 2.0	8.48	8.44	5.0	5.8
6		1.7	6.61	3.65	2.4	9.4
7	Established ponds with mixed	2.5	6.59	5.35	4.0	9.2
8	wetlands vegetation.	3.5	7.03	8.00	5.0	9.4
9		3.5	5.58	6.35	2.8	9.0
10		3.5	1.57	1.79	---	---
11	Small "bluff" ponds; #10,	2.3	0.27	0.20	---	---
12	#11, #12, #13, and #14 ponds	2.5	0.67	0.54	---	---
13	are operated in a series	2.5	1.08	0.88	---	---
14	mode.	1.0	1.20	0.39	2.5	6.1

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